

OCCURRENCE OF THE PROTOZOANS, *LANKESTERELLA HYLAE* AND
HAEMOGREGARINA SP., IN THE BLOOD OF THE GREEN TREE FROG,
LITORIA CAERULEA

B.L.J. DELVINQUIER

Delvinquier, B.L.J. 1989 11 13: Occurrence of the protozoans, *Lankesterella hylae* and *Haemogregarina* sp., in the blood of the green tree frog, *Litoria caerulea*. *Mem. Qd Mus.* 27(2):267-274. Brisbane. ISSN 0079-8835.

Of 62 green tree frogs, *Litoria caerulea*, collected in Queensland, 20 (32.25%) were found infected with sporozoites of *Lankesterella hylae* in their blood and a further 2 (3%) had gametocytes of *Haemogregarina* sp. A single specimen from the Darwin district, Northern Territory, was negative for both parasites. A total of 594 specimens of 60 species of native anurans and 267 specimens of the introduced cane toad, *Bufo marinus*, proved negative for intraerythrocytic protozoans. It is suggested that there is a strict host specificity for these haemoproteozoans.

□ *Lankesterella hylae*, *Haemogregarina* sp., *Litoria caerulea*, haemoproteozoans, Hylidae, Australia.

B.L.J. Delvinquier, Department of Parasitology, University of Queensland, St Lucia, Queensland 4067, Australia; present address: Department of Zoology, University of the Witwatersrand, PO WITS, Johannesburg 2050, South Africa; 10 February, 1988

Lankesterella hylae is the only intraerythrocytic protozoan described from Australian anurans. Cleland and Johnston (1910) described it from the red blood cells of three out of five *Litoria caerulea* from Sydney. They reported the parasite was 9-11 by 1.6-3 μm , crescentic with a band-like and reticular nucleus, which is often nearer one end than the other, and with a bulge containing a vacuole near the middle of the body. The parasite took various positions in the erythrocyte but did not distort or enlarge it, although the nucleus of the red blood cell was more or less displaced. They also noted double and triple infections and that the crescentic appearance was lost in free forms. The organism was again recorded in one out of three *L. caerulea* from Eidsvold, Queensland, by Cleland (1914) and from Brisbane as 'very common' by Johnston (1916). Mackerras and Mackerras (1961) found it in one out of ten specimens from Brisbane and six out of thirteen from Sydney. They reported measurements of 9-11 by 2-3 μm for the most abundant forms and 6-8 by 2 μm for the small forms. They observed numerous free parasites in organ smears from the heavily infected frogs, and exoerythrocytic stages in the liver and spleen. These forms occurred in small macrophages and they 'were oval crescentic, or sausage-shaped, with band-like reticular nuclei, and with 1 or 2 vacuoles'. Stehbens (1966a) found it in the erythrocytes of twelve out of thirteen *L. caerulea* from Gin-Gin, Queensland. The sporozoites (7-11 by 1-3 μm) were slender but in a number, one end was slightly less blunt than the

other, the nucleus was usually near the centre of the parasite and sometimes nearer the blunt end. At each end of the nucleus, he observed colourless vacuoles. On the concave surface of the intraerythrocytic forms he often noticed a 'dome-like swelling at or near the level of the nucleus' but could not determine its nature. He also made some observations from wet blood smears and on liver and spleen smears. The ultrastructure of *L. hylae* was studied by Stehbens (1966b).

In contrast, numerous haemoproteozoans have been reported from *Bufo marinus*. This species of toad is of South American origin and was introduced into Queensland from Hawaii in 1935 in the hope that it would eradicate two species of devastating cane beetles (Mungomery, 1935, 1936). It is now widespread (Covacevich and Archer, 1975; Freeland, 1987). Hamerton (1932) reported *Lankesterella* associated with microfilaria in the blood of captive *Bufo marinus* in the collection of the Zoological Society of London. In 1934, he reported *Lankesterella* as a single infection and *Lankesterella* associated with 'Haemogregarines' in the blood of the same species. In South America, several species of *Haemogregarina* have been described in *Bufo marinus*. A complete list of the records for this toad is given in Table 1. However, none of the reported haemoproteozoans have been detected in Australia.

There is no record of the genus *Haemogregarina* in Australian anurans, but, in New Guinea, Ewers (1968) recorded 'hemogregarines' (= *Haemogregarina* Danilewsky, 1885, and *Hepatozoon*

Miller, 1908) in 13 out of 20 *Litoria infrafronata*, 7 out of 46 *Platymantis papuensis* and 6 out of 21 *Rana papuensis*. However, Walton (1964) did not include species of the genus *Hepatozoon* in his host-parasite list and, according to Manwell (1977) *Hepatozoon* occurs in mammals, birds and 'a number of cold-blooded vertebrates'.

MATERIALS AND METHODS

Frogs and toads were captured by hand at night using a spot light. Collections were made in 99 localities in all six States of mainland Australia between 1983 and 1985. Exact descriptions of the localities with longitude, latitude, and Grid Map Index, are in Delvinquier (1987). Within two to

TABLE 1. Intraerythrocytic protozoans reported in *Bufo marinus* in South America.

PARASITE	LOCALITY	AUTHORITY
<i>Haemogregarina aguai</i> Phisalix, 1930	Brazil	Phisalix 1930 ¹
<i>Haemogregarina bufomarinus</i> Niño, 1926	Argentina	Niño 1926
<i>Haemogregarina cayennensis</i> Léger, 1918	Guiana	Léger 1918a
	Brazil	Phisalix 1930
<i>Haemogregarina darlingi</i> Léger, 1918	Guiana	Léger 1918b
	Brazil	Phisalix 1930
	Venezuela Venezuela	Scorza <i>et al.</i> 1956 see Díaz-Ungría 1960
<i>Haemogregarina legeri</i> Scorza, Dagert and Arocha, 1956	Venezuela	Scorza <i>et al.</i> 1956
	Venezuela	see Díaz-Ungría 1960
<i>Haemogregarina</i> spp.	Panama (U.K.) ?	Darling 1912 ² Plimmer 1912a, 1912b Franca 1911 ³
	Guiana (U.K.)	Léger 1918b
	Brazil	Hamerton 1933, 1934 de Figueiredo and Simões Barbosa 1943
	Peru	Nickerson and Ayala 1982
<i>Lankesterella</i> sp.	(U.K.)	Hamerton 1932, 1934
<i>Karyolysus aguai</i> Scorza, Dagert and Arocha, 1956	Venezuela	Scorza <i>et al.</i> 1956
	Venezuela	see Díaz-Ungría 1960
<i>Schellackia balli</i> Le Bail and Landau, 1974	Guiana	Le Bail and Landau 1974
<i>Dactylosoma ranarum</i> (Kruse, 1890)	Costa Rica	Ruiz 1959
<i>Dactylosoma</i> sp.	Guiana	Le Bail and Landau 1974
<i>Cytamoeba bacterifera</i> Labbé, 1894	Peru	Lehmann 1966

1 Scorza *et al.* (1956) believed this was *Karyolysus aguai* [sic] because of 'its agamic cycle is carried through in endothelial cells'. See also entry for *Karyolysus aguai*.

2 Léger (1918b) reobserved it in *B. marinus* in Guiana and renamed it *Haemogregarina darlingi*.

3 According to Walton (1964), but he may have been misquoting the author or the date because I could not find the reference in *Zoological Record* or 'The Index-Catalogue of Medical and Veterinary Zoology'.

three days of their capture, each specimen was dissected after being anaesthetized with chloroform. Thin blood smears were fixed with methanol and stained with Giemsa 10% in sodium-potassium phosphate buffer at pH 7.0. In all, 924 specimens of 62 species in 5 families of anurans were examined for the presence of intraerythrocytic protozoans.

The numbers of frogs and toads dissected are as follows [nomenclature follows Cogger et al. (1983) and Czechura et al. (1987)]: BUFONIDAE: *Bufo marinus*, 267; HYLIDAE: *Cyclorana brevipes*, 1; *C. novaehollandiae*, 6; *Litoria alboguttata*, 1; *L. caerulea*, 63; *L. chloris*, 14; *L. cyclorhyncha*, 5; *L. dahlii*, 10; *L. dentata*, 5; *L. ewingii*, 3; *L. fallax*, 72; *L. gracilentata*, 5; *L. inermis*, 26; *L. infrafrenata*, 1; *L. latopalmata*, 20; *L. lesueuri*, 28; *L. moorei*, 1; *L. nannotis*, 2; *L. nasuta*, 36; *L. nigrofrenata*, 1; *L. nyakalensis*, 5; *L. pallida*, 21; *L. pearsoniana*, 3; *L. peronii*, 26; *L. raniformis*, 1; *L. revelata*, 2; *L. rheocola*, 11; *L. rothli*, 32; *L. rubella*, 26; *L. serrata*, 2; *L. tornieri*, 15; *L. tyleri*, 2; *L. verreauxii*, 1; *Nyctimystes dayi*, 10; MYOBATRACHIDAE: *Adelotus brevis*, 3; *Assa darlingtoni*, 4; *Limnodynastes convexiusculus*, 2; *L. dorsalis*, 3; *L. dumerilli*, 4; *L. ornatus*, 10; *L. peronii*, 21; *L. salmini*, 2; *L. tasmaniensis*, 13; *L. terraereginae*, 14; *Mixophyes fasciolatus*, 6; *M. iteratus*, 2; *M. schevilli*, 3; *Neobatrachus centralis*, 2; *N. pelobatoides*, 3; *N. pictus*, 4; *Pseudophryne bibronii*, 1; *P. coriacea*, 2; *Ranidella bilingua*, 9; *R. insignifera*, 1; *R. parinsignifera*, 20; *R. signifera*, 39; *Taudactylus acutirostris*, 3; *T. rheophilus*, 2; *Uperoleia laevigata*, 4; MICROHYLIDAE: *Cophixalus ornatus*, 6; *Sphenophryne robusta*, 2; RANIDAE: *Rana daemeli*, 4.

Measurements are followed in brackets by the standard deviation of the sample (SDS), and number of specimens measured (N).

RESULTS

Lankesterella hylae and *Haemogregarina* sp. were the only intraerythrocytic protozoans that I found in Australian anurans. Both occurred in the red blood cells of *Litoria caerulea*. None of the other intraerythrocytic protozoans, *Dactylosoma ranarum* (Kruse, 1890) and *Cytamoeba bacterifera* (Labbé, 1894) were found.

Lankesterella hylae (Cleland and Johnston, 1910)
(Figs 1,2,3)

MATERIAL EXAMINED

Commonwealth Institute of Health, University of

Sydney: *Lankesterella hylae* - *Litoria caerulea*, Sydney, 1909-10, 3 slides, Cleland and Johnston's collection [well stained specimens]; *Lankesterella hylae* - *Litoria caerulea*, 2 slides (well stained specimens on one slide; the other slide is labelled a 'scanty infection' but I did not find any specimens); *Lankesterella hylae* - *Litoria caerulea*, 2 slides, Mackerras and Mackerras's collection [well stained specimens]. Queensland Museum GL4863; United States National Museum 38856; British Museum (Natural History) 1987.1.19.1; Museum of Comparative Zoology (Harvard University) 8; all from *Litoria caerulea*, Kingaroy (151°51'E, 26°37'S; Grid Map Index: LR857550 9244-1), Queensland, April 1983.

DESCRIPTION

This protozoan was only observed in the erythrocytes of the common green tree frog, *Litoria caerulea*, in the localities listed in Table 2. Figure 1 gives the geographical distribution of *Litoria caerulea* based on Cogger (1983) with geographical records of the protozoan.

The sporozoite is a slender, crescentic form which measures on average (intracorpuscular form) 8.9 (SDS±1.7) by 2.0 µm (SDS±0.7) (N=33) (range: 5.8 to 14.6 by 0.7 to 3.6 µm). The cytoplasm is pale blue when stained with Giemsa and contains in the middle an oval vacuole surrounded by masses of chromatin. This vacuole can be large enough to deform the shape of the sporozoite and create a bulge in its outline. The band-like nucleus is situated near one end of the parasite (see Figs 2,3). I did not find it in the leucocytes.

Infections were scanty, with a mean of only 2.3% erythrocytes infected (N=4000 cells counted



FIG. 1. Geographical distribution of *Litoria caerulea* (stippled area) according to Cogger (1983) and records of *Lankesterella hylae* and *Haemogregarina* sp. Numbers refer to districts as in Table 2.

in smears stained with Giemsa). In the museum material, I found 2.0% erythrocytes infected in the three slides of Cleland and Johnston (N = 300), 1.7% in the well stained slide made by the anonymous collector (N = 100), and 6.6% in the two slides of Mackerras and Mackerras. Multiple infections, two sporozoites in one erythrocyte, were occasionally observed (see Fig. 3). A few free sporozoites were also seen. Erythrocytes were never deformed by the presence of the protozoan but the nucleus was slightly displaced.

COMMENTS

The form 1 observed in the erythrocytes of *Litoria caerulea* closely agrees with the description of the previous workers (Cleland and Johnston, 1910; Mackerras and Mackerras, 1961; Stehbens, 1966a).

Haemogregarina sp. of *Litoria caerulea* (Figs 1,4,5)

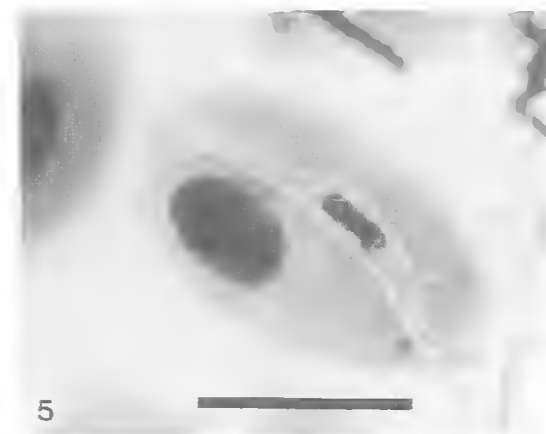
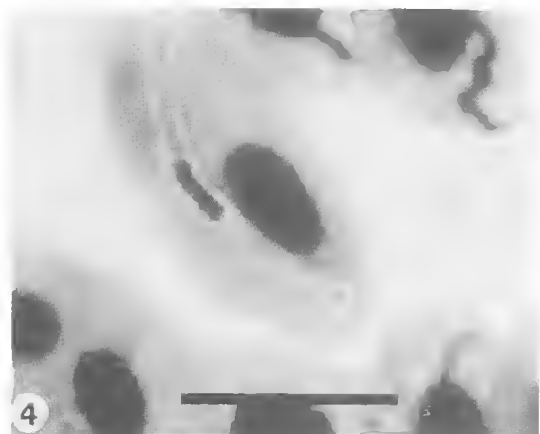
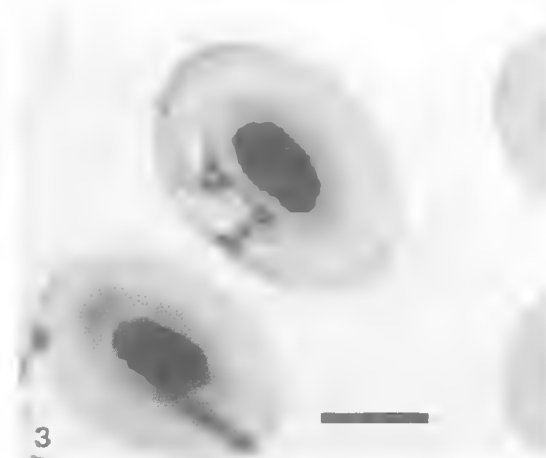
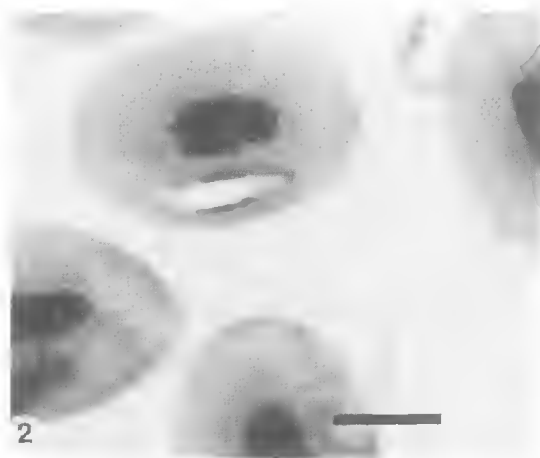
MATERIAL EXAMINED

Queensland Museum GL4864: *Litoria caerulea*, Bushy Creek, (145° 20'E, 16°36'S; Grid Map Index: CB223627 7964), Queensland, November 1983.

DESCRIPTION

I have observed this protozoan in only two specimens of *Litoria caerulea* from Bushy Creek, North Queensland (see Table 2). None of the 267 adult specimens of *Bufo marinus* were infected.

It has a narrow elongated body with rounded extremities. It is slightly bent around the nucleus of the erythrocyte. It measures on average 19.4



FIGS 2-5. 2: Single infection of *Lankesterella hylae* in an erythrocyte of *Litoria caerulea* from Kingaroy. Scale bar: 10 μ m. 3: Double infection of *Lankesterella hylae* in an erythrocyte of *Litoria caerulea* from Kingaroy. Scale bar: 10 μ m. 4-5: *Haemogregarina* sp. in an erythrocyte of *Litoria caerulea* from Bushy Creek. Scale bar: 20 μ m.

(SDS = 2.2) by $2.0 \mu\text{m}$ (SDS = 0.4) (N = 23) (range: 16.0 to 23.3 by 1.5 to $2.9 \mu\text{m}$). The nucleus is situated in about the middle of the cell (see Figs 4 and 5). No bulge was observed. It typically deforms the erythrocyte it invades by elongating it. Only single infections were found in the erythrocytes. I observed the parasite in an average of 3% of the host erythrocytes (N = 100).

COMMENTS

I consider the form that I observed to be the gametocyte stage of a species of *Haemogregarina*. It has the features typical of the gametocytes of other species of that genus: intraerythrocytic, elongated, slender with rounded extremities, nucleus situated in the middle or near the narrower extremity.

TABLE 2. Occurrence and geographical distribution of *Lankesterella hylae* and *Haemogregarina* sp. in *Litoria caerulea*.

Localities	Collection dates	Number collected	Number infected
QUEENSLAND			
1. Brisbane district			
St Lucia	Mar. 1983	1	0
	Apr. 1983	1	0
	Sep. 1983	2	0
Chapel Hill	Mar. 1983	1	0
2. Kingaroy district			
Kingaroy	Apr. 1983	11	8
Kumbia	Jan. 1984	2	2
Wooroolin	Jan. 1984	2	0
3. Gympie district			
Gunalda	Apr. 1983	5	5
4. Gayndah district			
Barambah Creek	Jan. 1984	2	0
Gayndah	Jan. 1984	1	0
Gayndah-Eidsvold Road	Jan. 1984	5	2
5. Bundaberg district			
Bundaberg	Jul. 1983	11	0
6. Rockhampton district			
Yeppoon	Aug. 1983	4	0
7. Mackay district			
Eungella-Mackay Road	Nov. 1983	1	0
Marian	Nov. 1983	1	1
8. Townsville district			
Townsville	Nov. 1983	4	0
9. Atherton district			
Emerald Creek	Nov. 1983	2	1
Mareeba	Dec. 1984	1	1
Bushy Creek	Nov. 1983	4	2*
Herberton	Dec. 1984	1	0
NORTHERN TERRITORY			
1. Darwin district			
Wildman River	Jun. 1985	1	0

* *Haemogregarina* sp.

DISCUSSION

From my observations, as well as those of the previous workers, (Cleland and Johnston, 1910; Cleland, 1914; Johnston, 1916; Mackerras and Mackerras, 1961; Stehbens, 1966a), *Lankesterella hylae* occurs only in *Litoria caerulea*. Furthermore, this species of frog is so far the only Australian anuran to be found infected with a species of *Haemogregarina*. The absence of *Lankesterella* and of *Haemogregarina* in *Bufo marinus* is probably explained by a lack of infected specimens among the original stock (101 toads, see Mungomery, 1935), or to the absence of a suitable vector.

The highly restricted occurrence of *Lankesterella* and of *Haemogregarina* in Australian anurans calls for remark. Cleland and Johnston (1910), having noticed the common occurrence of *Lankesterella hylae* in the green tree frog *Litoria caerulea* and its absence in the blood of *Litoria aurea*, suggested that either the parasite was host specific, or that the intermediate host could not have access to *L. aurea* due to differences in the living habits of the two frog species. However, they regarded the latter hypothesis as unlikely. They also suggested that a leech was the intermediate host. Stehbens (1966a) thought that an insect such as a mosquito acted as the intermediate host. He had discovered intracellular parasites in the small intestine of the frog, within unidentified cells that he regarded as probably macrophages, or possibly enlarged and proliferated endothelial cells. He suggested that infection took place with ingestion by the green tree frog of an infected mosquito. The sporozoites released by the mosquito would enter the intestinal wall of the frog and develop into schizonts. Farmer (1980) considered that leeches were unlikely because 'the hosts are tree frogs' and instead suggested blood-sucking insects. On the other hand, Nöller (1913, 1920) demonstrated that a leech, *Hemiclepsis marginata*, passively transmits *Lankesterella minima* to *Rana esculenta* when the frog eats the leech. There is no evidence that a blood-sucking insect rather than a leech is the intermediate host in the life cycle of *L. hylae*.

L. caerulea has arboreal habits and is often found near houses where it is able to find water (for example in toilets and water tanks). I rarely found it near ponds, and when I did, it was after a warm rain shower at night during the breeding season. Other related arboreal species, such as the very common *Litoria fallax*, *L. peronii*, *L. rubella*, are sometimes found near houses in the same conditions. The former two species are also very

common in ponds and are calling most nights in summer whereas the green tree frog usually calls only after a warm shower. *L. rubella* was often found sitting, as was *L. caerulea*, on the road at night. From my own observations of the habits of species closely related to *L. caerulea*, I do not think that living habits of the green tree frog differ from these frogs in a way sufficient to explain the absence of the genus *Lankesterella* from other Australian anurans. I am therefore inclined to follow the first suggestion of Cleland and Johnston (1910) and believe that specificity of *L. hylae* is determined, but in an unknown way, by its ability to develop only in *L. caerulea*.

In the case of the genus *Haemogregarina*, the infection begins when an invertebrate blood-sucking vector bites the vertebrate host (Reichenow, 1910). Despite this difference, *Haemogregarina* sp. appears to be like *Lankesterella hylae* in being restricted to *L. caerulea*. I suggest that the specificity of *Haemogregarina* is determined in the same way as in *Lankesterella*.

The finding of 'hemogregarines' in *Litoria infrafronata* from New Guinea by Ewers (1968) is interesting. *L. infrafronata* is a hylid also found in North Queensland 'in and around the remnants of rainforest on the eastern coastline of the Cape York' (Tyler, 1976) and by its size and shape resembles very much *Litoria caerulea*. It may be that the Australian species also harbours some haemogregarines but I only captured one specimen of *L. infrafronata* and it was negative. He also found 'hemogregarines' in the blood of two ranids, *Rana papuensis* and *Platymanis papuensis*. In Australia, there is only one ranid, *Rana daemeli* and the four specimens I collected were also negative. Records of the genera *Lankesterella* and *Haemogregarina* are mainly in ranids and in bufonids (see Walton, 1964).

ACKNOWLEDGEMENTS

Dr H.M.D. Hoyte is thanked for his advice and comments on the drafts of the manuscript; as are Mr F.W. Aslin, Dr G.N. Berry, Dr W.J. Freeland, Mr W. Hosmer, Dr M.K. Jones, Dr K. Martin, Mr G. Stewart, Mr M.J. Tyler, and Dr G. Watson, for their assistance in collecting anurans, and Dr G. Ingram for help in the confirmation of the anuran specimens. This work was supported by grants from the Australian Museum in Sydney and the Mark Mitchell Foundation in Adelaide.

LITERATURE CITED

- CLELAND, J.B. 1914. The haematozoa of Australian batrachians No 2. *J. Proc. R. Soc. N.S.W.* 48: 412-4.
- CLELAND, J.B. AND JOHNSTON, T.H. 1910. The haematozoa of Australian batrachians No 1. *J. Proc. R. Soc. N.S.W.* 44: 252-60.
- COGGER, H.G. 1983. 'Reptiles and amphibians of Australia'. (A.H. & A.W. Reed: Frenchs Forest). 660 pp.
- COGGER, H.G., CAMERON, E.E. AND COGGER, H.M. 1983. 'Zoological catalogue of Australia. Volume 1. Amphibia and Reptilia'. (Bureau of Fauna and Flora: Canberra), vi 313 pp.
- COVACEVICH, J. AND ARCHER, M. 1975. The distribution of the cane toad, *Bufo marinus*, in Australia and its effects on indigenous vertebrates. *Mem. Qd Mus.* 17(2): 305-310, pl. 41.
- CZECHURA, G.V., INGRAM, G.J. AND LIEM, D.S. 1987. The genus *Nyctimystes* (Anura: Hylidae) in Australia. *Rec. Aust. Mus.* 39: 333-338.
- DARLING, S.T. 1912. Some blood parasites (*Haemoproteus* and *Haemogregarina*). *Bull. Soc. Path. exot.* 5: 71-3.
- DELVINQUIER, B.L.J. 1987. Protozoan parasites of the Australian Anura. Unpublished PhD thesis, University of Queensland, xxv 432 pp.
- DÍAZ-UNGRÍA, C. 1960. Parasitología venezolana. *Fundación La Salle de Ciencia Naturales Caracas, Monographs* 1: 1-657.
- EWERS, W.H. 1968. Blood parasites of some New Guinea reptiles and Amphibia. *J. Parasit.* 54: 172-4.
- FARMER, J.N. 1980. 'The Protozoa. Introduction to protozoology'. (C.V. Mosby Company: St Louis). ix 732 pp.
- FIGUEIREDO, DE A. AND SIMÕES BARBOSA, F.A. 1943. Sobre uma hemogregarina parasita das hematias de *Bufo marinus* [sic]. *Revta Acad. Med. Odon. Farm.* 1: 87-8.
- FRANCA, C. 1911. [quoted by Walton, (1964)].
- FREELAND, W.J. 1987. Cane Toads and the balance of nature. *Wildlife Australia* 24(3): 12-14.
- HAMERTON, A.E. 1932. Report on the deaths occurring in the Society's gardens during the year 1931. *Proc. zool. Soc. Lond.* 1932: 613-38.
1933. Report on the deaths occurring in the Society's gardens during the year 1932. *Proc. zool. Soc. Lond.* 1933: 451-82.
1934. Report on the deaths occurring in the Society's gardens during the year 1933. *Proc. zool. Soc. Lond.* 1934: 389-422.
- KRUSE, W. 1890. Ueber Blutparasiten. *Arch. path. Anat.* 120: 541-60; 121: 359-72. [Not seen: quoted by Wenyon (1926) - reference confirmed in 'The Index Catalogue of Medical and Veterinary Zoology', 1946, Part 6, authors: K to Kyzer].
- JOHNSTON, T.H. 1916. A census of the endoparasites recorded as occurring in Queensland, arranged under their hosts. *Proc. R. Soc. Qd* 28: 31-79.
- LABBÉ, A. 1894. Recherches zoologiques et biologiques sur les parasites endoglobulaires du sang des vertébrés. *Archs Zool. exp. gn.* 2: 55-258.
- LE BAIL, O. AND LANDAU, I. 1974. Description et cycle biologique expérimental de *Schellackia balli* n.sp. (Lankesterellidae) parasite de crapauds de Guyane. *Annls Parasit. hum. comp.* 49: 663-8.
- LÉGER, M. 1918a. Hémogrégarine de *Bufo marinus* L. *Bull. Soc. Path. exot.* 11: 687-90.
- 1918b. Hémogrégarines de crapauds à la Guyane française. *Bull. Soc. Path. exot.* 11: 788-91.
- LEHMANN, D.L. 1966. Two blood parasites of Peruvian Amphibia. *J. Parasit.* 52: 613.
- MACKERRAS, M.J. AND MACKERRAS, I.M. 1961. The haematozoa of Australian frogs and fish. *Aus. J. Zool.* 9: 123-39.
- MANWELL, R.D. 1977. Gregarines and haemogregarines. pp. 1-32. In Kreier, J.P. (ed.), 'Parasitic Protozoa, volume III'. (Academic Press: New York).
- MILLER, W.W. 1908. *Hepatozoon perniciosum* (n.g., n.sp.); a haemogregarine pathogenic for white rats; with a description of the sexual cycle in the intermediate host, a mite (*Lelaps echidninus*). *Bull. hyg. Lab.* 46: 51 pp. [Not seen: quoted by Manwell (1977) - reference confirmed in 'The Index Catalogue of Medical and Veterinary Zoology', 1948, Part 10, authors: M to Mysh].
- MUNGOMERY, R.W. 1935. A short note on the breeding of *Bufo marinus* in captivity. *Proceedings of the Fifth Congress of the International Society of Sugar Cane Technologists 1935*: 589-91.
1936. A survey of the breeding habits of the giant toad, (*Bufo marinus* L), and notes on its progress since its introduction into Queensland. *Proceedings of the Seventh Annual Conference of the Queensland Society of Sugar Cane Technologists 1936*: 63-74.
- NICKERSON, M.A. AND AYALA, S. 1982. Amphibia/Reptilia hemoparasites. *Herpetol. Rev.* 13: 94.
- NINO, F.L. 1926. *Hemogregarina* [sic] *bufo marinus* en los sapos de Buenos Aires. *Prensa méd. argent.* 12: 944-52.
- NÖLLER, W. 1913. Die Blütprotozoen des Wasserfrosches und ihre Übertragung. *Arch. Protistenk.* 31: 169-239.
1920. Kleine Beobachtungen an parasitischen Protozoen. (Zugleich vorläufige Mitteilung über die Befruchtung und Sporogonie von *Lankesterella minima* Chaussat). *Arch. Protistenk.* 41: 169-89.
- PHISALIX, M. 1930. Les hémogrégarines du *Bufo aqua* Ltr. (syn. *Bufo marinus* L.). *Bull. Soc. Path. exot.* 23: 372-7.
- PLIMMER, H.G. 1912a. On the blood parasites found in animals in the zoological gardens during the four years 1908-1911. *Proc. zool. Soc. Lond.* 1912: 406-19.
- 1912b. III. The president's address: On certain blood parasites. *Jl R. microsc. Soc.* 1912: 133-50.
- REICHENOW, E. 1910. Der Zeugungskreis der *Haemogregarina stepanowi*. *Sber. naturf. Ges. Berl.* 1: 1-4.
- RUIZ, A. 1959. Sobre la presencia de un *Dactylosoma* en *Bufo marinus*. *Revta Biol. trop.* 7: 113-7.
- SCORZA, J.V., DAGERT, C. AND AROCHA, L.I. 1956.

- Estudo sôbre hemoparasitos de *Bufo marinus* L. da Venezuela. *Mems Inst. Oswaldo Crus.* 54: 373-85.
- STEBBENS, W.E. 1966a. Observations on *Lankesterella hylae*. *J. Protozool.* 13: 59-62.
- 1966b. The ultrastructure of *Lankesterella hylae*. *J. Protozool.* 13: 63-73.
- TYLER, M.J. 1976. 'Frogs'. (William Collins: Sydney). 256 pp.
- WALTON, A.C. 1964. The parasites of Amphibia. Wildlife Diseases (microcard publication) Knox College, Galesburg, Illinois 39-40.
- WENYON, C.M. 1926. 'Protozoology. A manual for medical men, veterinarians and zoologists'. (Bailliere, Tindall and Cox: London). xvi 1563 pp.